PATENT SPECIFICATION

(11) 1 276 458

1276458

DRAWINGS ATTACHED

(21) Application No. 13628/70 (22) Filed 20 March 1970
(31) Convention Application No. 823 924 (32) Filed 12 May 1969
(31) Convention Application No. 864 927 (32) Filed 10 Sept. 1969 in
(33) United States of America (US)
(45) Complete Specification published 1 June 1972
(51) International Classification F01D 5/18; F16H 41/28; F42B 15/00; B64C 3/26
(52) Index at acceptance
F1T 2A 2F2A 2F2B 2F3
B3A 130 137 166
B7V 1K
B7W 28 6A5
E1K 1B1A 1B1B 1B1E 1B1F 1B1G 1B1U 3B 3D
F2C 10B2
F3A 2K

(54) HOLLOW MEMBERS

(71) We, CYCLOPS CORPORATION, Universal-Cyclops Speciality Steel Division, a corporation of the Commonwealth of Pennsylvania, United States of America, of Pittsburgh, Pennsylvania, United States of America, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to hollow members and more particularly, though not exclusively, to aerofoil members such as vanes and blades employed in gas turbines, steam turbines, torque converters and the like.

Current power sources such as steam and gas turbines and power conversion units such as torque converters all have specially shaped parts which aid in transforming the input energy into a mechanical output energy such as providing mechanical torque to a rotary shaft. These specially shaped parts through the years have been termed blades where they are rotating members and vanes where they are stationary.

The shape requirements for these blades and vanes varies with the intended application. Even within a given power application, the shape of the various members varies. For example, many gas turbines employ several compressor stages, each stage potentially having a differing shape requirement for its blades and vanes.

Many blades and vanes are tapered to provide a more streamlined shape to accomplish a more efficient operation. This is typical in an axial flow gas turbine where the portion of the blades and vanes exposed to the gas flow are called aerofoil sections and are often tapered to afford the greatest efficiency in transforming heat energy into mechanical energy.

In addition to the shape requirements, the material selection is also very important since the weight and the chemical and physical property requirements also vary with the intended application. Many solid vanes and blades must be made of expensive metals or metal alloys because a comparable less expensive solid, e.g. steel, is just too heavy or does not possess the properties necessary for efficient operation.

These same requirements as set out hereinbefore are also applicable to missile fins, propellers and other similar members which are affected by the flow of air or other media acting upon their surfaces.

To meet these various requirements, many manufacturing methods have been employed either singly or in combination incorporating both solid sections and solid or joined hollow sections. These manufacturing methods used heretofore include but are not limited to forging, casting, cold drawing, extruding, cold rolling and machining.

According to the present invention, there is provided a hollow member comprising at least two connected components which are joined together to merge smoothly into each other, each or at least two of said components having an enlarged recessed end portion which mates with and has a connection to an end portion of another or the other component, the last-mentioned end portion being neither enlarged nor recessed, said connections being positioned

inward of the extreme end of the enlarged recessed end portion.

The individual components may be processed to produce a resultant tapered member. Internal supports may be provided where requirements so dictate. A further modification includes filling the hollow portion of the member with a filler material different from the base material.

The invention is described, merely by way of example, with reference to the accompanying drawings, in which:—

Figure 1 is a section through a hollow aerofoil member in accordance with a first embodiment of this invention,

Figure 2 is an isometric view of the upper component of the aerofoil member of Figure 1,

Figure 3 is a fragmentary section through an enlarged, recessed and rounded edge for use with an aerofoil member as shown in Figure 1,

Figure 4 is a fragmentary section, similar to Figure 3, but showing an enlarged, recessed and chamfered edge,

Figure 5 is a fragmentary section, similar to Figure 3, but showing an enlarged, recessed and square edge.

Figure 6 is an isometric view of a tapered aerofoil member,

Figure 7 is a section through a hollow aerofoil member according to a further preferred embodiment of this invention and having an internal supporting rib,

Figure 8 is a section of a modification, showing a hollow aerofoil member having an integral supporting rib,

Figure 9 is a section of a further modification, showing an aerofoil member containing a filler in the aerofoil's hollow interior,

Figure 10 is an isometric view of a tapered fin made in accordance with the invention,

Figure 11 is a full section through the fin of Figure 10,

Figure 12 is a section through a T-section hollow member,

Figure 13 is a section through another hollow member,

Figure 14 is a section through an I-section hollow member,

Figure 15 is a section through another hollow member,

Figure 16 is a section through still another hollow member, and

Figure 17 is a section through a U-section hollow member.

It will be appreciated by those skilled in the art that this invention is adaptable to various gas and steam turbine blades and vanes, various blades for torque converters, helicopter rotors; missile fins, wings and aerodynamic components in general, including hollow members adapted to support such parts.

A typical aerofoil member 10 of this invention is shown in Figure 1. Aerofoil member 10 is hollow and comprises two connected components, namely, upper component 11 and lower component 12. Each component 11 and 12 has an enlarged recessed end portion 13 and 14, respectively, and an end portion 15 and 16 which is neither enlarged nor recessed, respectively. The end portion 15 of upper component 11 is illustrated in Figure 2. The particular edge geometry desired can be obtained by the various precision rolling, extrusion, cold drawing or other forming techniques. In other words, the desired end portion 13 can be formed by one of these above-identified methods while the portion 15 can likewise be formed by one of these methods which imparts a required shape to the balance of the component. Once rolled, the component is formed by well-known techniques to the desired shape such as the slight curvature illustrated in Figure 2.

There are a variety of enlarged, recessed end portions or geometries which may be employed, such as those illustrated in Figures 3 to 5, depending upon the ultimate desired use and requirements of the aerofoil member. Illustrated in Figure 3 is a rounded edge configuration 17; whereas Figures 4 and 5 illustrate a chamfered edge 18 and a square edge 19, respectively. The rounded edge configuration is most often employed where a streamline effect is required, such as turbine blades; whereas the other edge configurations are more applicable to structural support members.

The components 11 and 12 are joined by brazing, welding or other connecting techniques. The joining of the two components is effected in such a way that the enlarged, recessed end portion of component 11 is joined to the portion 16 of component 12 and the portion 15 of component 11 is joined to the enlarged recessed end portion 14 of component 12. This then balances the weight distribution of the aerofoil member 10 by having a heavier section positioned at both the leading and trailing ends of the aerofoil member 10.

The enlarged, recessed end portion is shaped so that a small recess 20 is present inward of the extreme end of the edge to mate with the end of the non-recessed portion of the second component (see Figures 1 and 2). This then enables the components to merge smoothly into one another and maintains the streamline nature of the aerofoil member without placing the connection at the extreme ends where it would be more susceptible to damage.

The exact connecting technique is, of course, dependent on the materials employed. Since the rolling and forming processes are adaptable to all wrought metals, the choice of materials is large and will be dependent on the weight, physical or chemical characteristics of the particular intended application.

The aerofoil member according to a preferred embodiment of this invention may also be tapered as illustrated in Figure 6. To

achieve this taper, the individual upper and lower components 22 and 23 are blanked at an angle to a somewhat trapezoidal shape prior to connecting. For example, the blank of component 11 shown in Figure 2 could be prepared for a tapered aerofoil member 21 by removing by cutting or blanking the triangular section designated by sides AB, AC, CB or triangle ABC in Figure 2. Then by doing the same for the second component and joining the remaining somewhat trapezoidally shaped blanks, as described hereinbefore, a hollow tapered aerofoil member 21 is formed. Where the aerofoil members require forming prior to the joining, this may be accomplished either during or subsequent to the blanking or cutting operation.

It will be noted that the portion of the wrought metal removed for a tapered blank is relatively small compared to the entire component, thereby maintaining an appreciable yield and efficiency advantage over tapered aerofoil members formed by other techniques, for example, forging and machining a solid blank.

Where size, strength or material requirements are such that an aerofoil member, as described hereinbefore, will not meet the requirements of a particular application, a mid-chord supporting rib such as that illustrated in Figure 7 can be inserted in the hollow portion of the aerofoil section to give additional support. Aerofoil member 24 is formed in the same way as the earlier embodiments having an upper component 26 and a lower connected component 27 connected in the same manner as the above described embodiments. A supporting rib 25 is positioned in the hollow portion of the aerofoil section between the aerofoil section ends and is secured to both the upper and lower components by means compatible with the particular material employed.

The rib can also be made an integral part of the components of the aerofoil member, as illustrated in Figure 8. Aerofoil member 28 comprises three components 29, 30 and 31. Component 29 has an enlarged, recessed end portion 32 which mates with a non-enlarged, non-recessed end portion 33 of component 30. In turn, a non-enlarged, non-recessed end portion 34 of component 29 mates with an enlarged, recessed end portion 35 of component 30. In this case, end portion 35 actually constitutes the integral supporting rib when the aerofoil member 28 is completely formed. Component 31 which has two non-recessed, non-enlarged ends is also connected to enlarged, recessed end portion 35. The result is that an internally supported aerofoil member 28 is formed whereby two of three components are formed by connecting non-enlarged, non-recessed end portions to enlarged, recessed end portions and the third component which has only non-enlarged, non-recessed end portions is shaped to mate with the enlarged, recessed end portion of the component forming the integral supporting rib.

The aerofoil member may also encapsulate a filler material different from the material of the aerofoil member, which filler material fills the hollow portion of the aerofoil member 36 as shown in Figure 9. Aerofoil member 36 comprises an upper component 37 and a lower component 38 which are shaped and connected as in the earlier described embodiments. The cavity area of the aerfoil member 36 is filled with a matrix of filler material 39. This filler material 39 may be a material of smaller density than the wrought metal components to enhance the strength without materially adding to the weight or it may be a highly heat-transmitting substance rapidly to remove heat from the outer components. Again, the particular application will dictate the choice of material for the filler.

A plurality of components shaped and connected in the manner described hereinbefore can be employed to construct various hollow members such as missile fins. There is illustrated in Figures 10 and 11 a hollow fin 40 having three components 41, 42 and 43. Each component as in the earlier embodiments has an enlarged recessed end portion and a non-enlarged, non-recessed end portion. These components are blanked, as shown in the earlier described embodiments, to form a tapered fin (see Figure 10). Each component is connected so that a non-enlarged, non-recessed end portion of one component is mated with and connected to an enlarged, recessed end portion of another component, etc. However, in this embodiment, two of the components 41 and 42 contain a right angle bend so that a fin is formed having a web a base section. It will be clear to those skilled in the art that a plurality of individual components as described above can be connected to form a variety of these hollow members and that the hollow member need not be limited to just two components.

In Figure 12 to Figure 17, there are shown sections of some hollow members which can be constructed in accordance with this invention. While these various hollow members differ in shape and number of components, each one is constructed from components having an enlarged, recessed end portion and a non-enlarged, non-recessed end portion. Just as in the earlier embodiments, these hollow members can be tapered to meet particular applications where strength and weight requirements vary from one end of the member to the other.

In Figures 12 and 15, there are illustrated three component hollow members. The hollow member in Figure 12 has components numbered 50, 51 and 52 and in Figure 15, the components are numbered 59, 60 and 61. Two component hollow members are illustrated in Figure 13, Figure 16 and Figure 17. In Figure

13, the components are numbered 53 and 54; and in Figure 16, the components are numbered 62 and 63; and in Figure 17, the components are numbered 64 and 65. A four component system is illustrated in Figure 14 where the components are numbered 55, 56, 57 and 58.

It will be appreciated that the preferred embodiments of this invention, by providing a hollow member, result in a lighter product as compared to a similar solid product of identical configuration and of the same metal. This in turn presents greater freedom in material selection and in substitution of materials. The said embodiments further provide for high volume production because of the various processes available to make the several requisite components of the hollow member; they are readily adapted to producing tapered hollow members; and provide a well balanced and efficiently operating member by having a section of increased weight present both at the leading and trailing edges of an aerofoil member. Because of this increased efficiency, either smaller or fewer members need be employed to achieve the same output, or in the alternative a smaller engine may be employed to maintain the same output. The said embodiments provide further advantages in strength and design since the joining of the members whether by welding or other means occurs in an area spaced inwardly from the extreme ends of the aerofoil members; they provide simplified means to control the temperature, i.e., either to cool or heat the aerofoil members, and permit the use of wrought metals regardless of their specific composition.

A particular advantage of these embodiments is the ability to produce the required configurations in long bars or strips by various processes, such as precision rolling, extrusion, cold rolling or other methods of forming. These long lengths may then be cut or blanked to the exact length required for the particular aerofoil, thus further increasing the high productivity of these members.

The said embodiments also provide a hollow member which may be fastened to a base member by various methods. It may be welded to the inner face of the base, inserted through a hole in the base and flanges bent and welded or brazed to hold it in place, or inserted through a hole in the base with the outer portion chamfered or flanged and having the outer portion of the hollow member similarly chamfered and flanged and welded, brazed, or fastened in position by other means.

WHAT WE CLAIM IS:—

1. A hollow member comprising at least two connected components which are joined together to merge smoothly into each other, each or at least two of said components having an enlarged recessed end portion which mates with and has a connection to an end portion of another or the other component, the last-mentioned end portion being neither enlarged nor recessed, said connection being positioned inward of the extreme end of the enlarged recessed end portion.

2. A member as claimed in claim 1 wherein there are only two connected wrought metal components, each of said components having a said enlarged recessed end portion and a said last-mentioned end portion, so that the enlarged recessed end portion of the first component mates with and is connected to the last-mentioned end portion of the second component and the enlarged recessed end portion of the second component mates with and is connected to the last-mentioned end portion of the first component.

3. A member as claimed in claim 1 or 2 in which the member is an aerofoil member.

4. A member as claimed in any preceding claim wherein each component is trapezoidally shaped to form a tapered member when said components are joined to form said member.

5. A member as claimed in claim 1 wherein there are three components, two of said components having a bend to form opposed outwardly flaring sections, said outwardly flaring sections being connected to the third component to form a base of, and the two components being connected to each other to form a web of, the said member.

6. A member as claimed in claim 2 wherein an internal supporting rib is positioned within the hollow portion of the member, is in contact with both components and is connected thereto.

7. A member as claimed in any preceding claim wherein a filler material completely fills the hollow portion of the member and is permanently affixed thereto, said filler material being of less dense and more heat transmitting material than that of said components.

8. A member as claimed in claim 1 wherein there are three components one of which is formed with an integral rib which has three recesses, one of said components having its ends connected to two of the three recesses of said rib.

9. A member as claimed in any preceding claim wherein each of the components are tapered prior to being joined so that a tapered member is formed after the components are joined.

10. A hollow member substantially as hereinbefore described with reference to and as shown in the accompanying drawings.

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Printed for Her Majesty's Stationery Office by the Courier Press, Leamington Spa, 1972.
Published by the Patent Office, 25 Southampton Buildings, London, WC2A 1AY, from which copies may be obtained.

1276458 COMPLETE SPECIFICATION

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Sheet 1

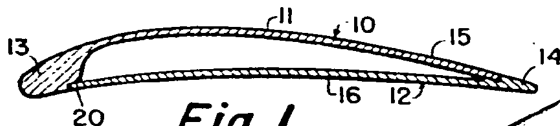

Fig. 1

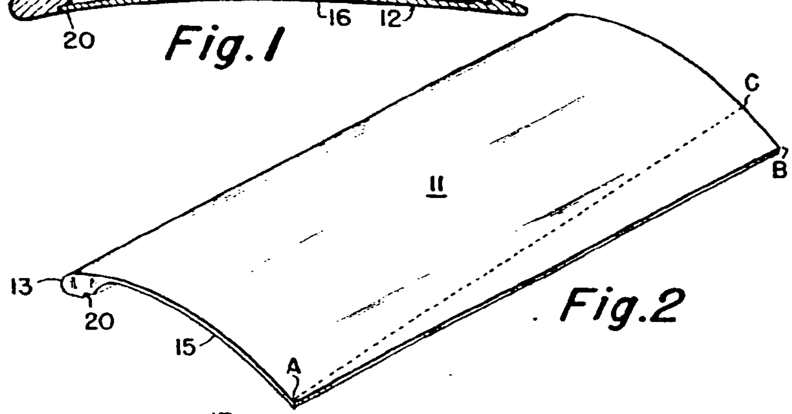

Fig. 2

Fig. 3

Fig. 4

Fig. 5

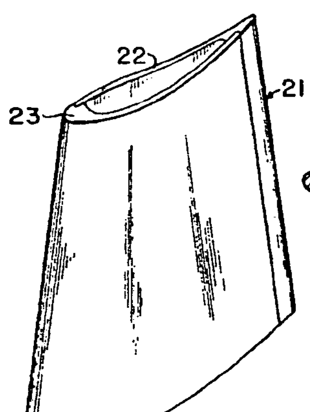

Fig. 6

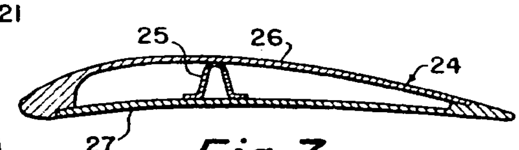

Fig. 7

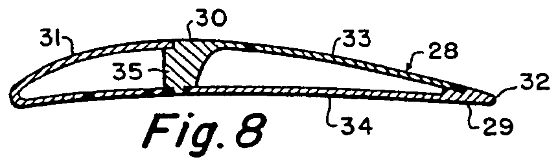

Fig. 8

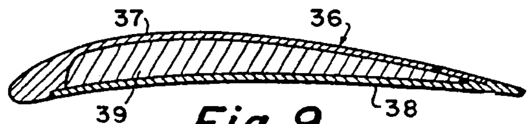

Fig. 9

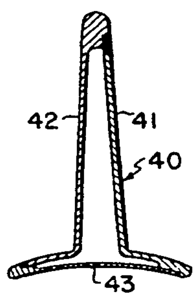

Fig. 11

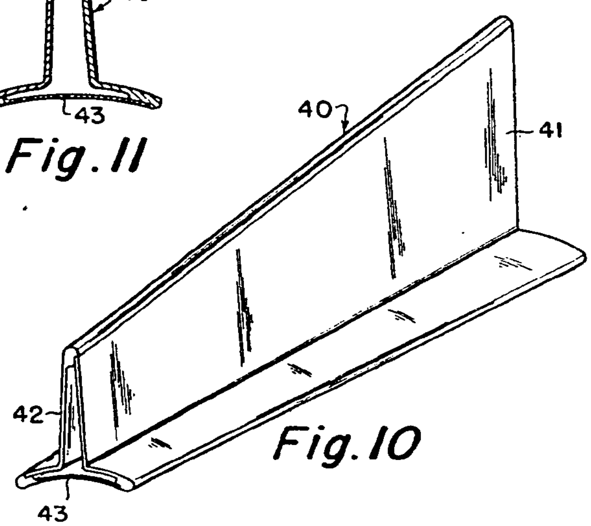

Fig. 10

1276458 COMPLETE SPECIFICATION

3 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 3

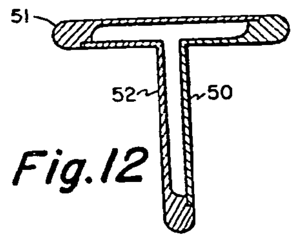

Fig. 12

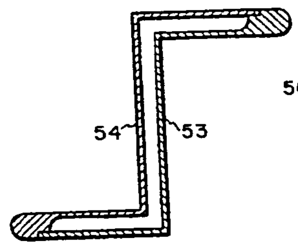

Fig. 13

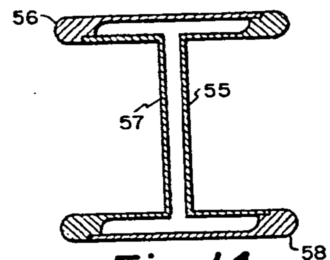

Fig. 14

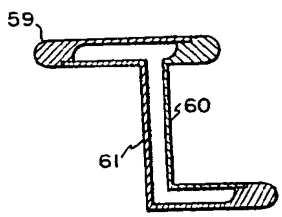

Fig. 15

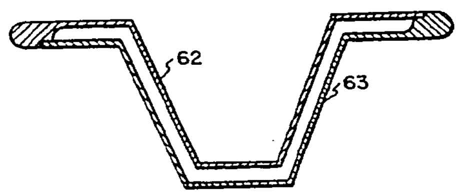

Fig. 16

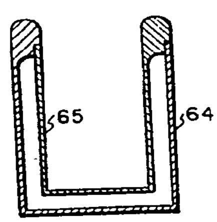

Fig. 17